The Utility of the Virtual Reality in Autistic Disorder Treatment

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Abstract. Autistic disorder patients lack the social communication abilities and need interventional therapy to alleviate such symptoms. The cost of health care and treatment across the lifespan of patients were up to $3.2 million which places a crushing burden on the poor patients and their families. To relieve the symptoms of disease and reduce the financial pressure of the patients, many methods were proposed. The normal therapy is proceeding under the instruction of professional doctors in the hospital. Each person need to spend 6–8 h in the specialized institutions. Given the cost of treatment and time, the treatment could not carry out continually which could lead to reducing the curative effectiveness. The current study explores the utility of the virtual reality interventions to the autistic disorder patients. In the virtual environment, the patients could be receiving treatment continually and practice their social communication abilities in different social scenes. To generate immersive virtual social environment, a VR engine (Unity3D 5.0) were used. Some typical social communication scenes were also established which include the classroom, shopping mall and hospital. In these virtual scenes, the ASD patients were required to communicate with artificial intelligence (AI) players and finish some tasks. The coach which played by the researcher or expert would send appropriate instructions to help the patient when they encounter the difficulties. Two different statistic tables will be collected twice: one is before the training, the other one is after the training. The two checklists are Autism Behavior Scale (ABS) table and Childhood Autism Rating Scale (CARS) table. By comparing the scores which achieved in different time, researchers could assess the result of treatment and changing the content of the treatment in time. Four ASD children who had confirmed ASD diagnoses from a clinical doctor take part in this experiment. Informed consent was obtained from the parents before participation. The average age of the subjects is 6 (±1). These volunteers were asked to execute nine tasks in different social scenes, which include communicate with strange teachers, sellers and doctors. All these tasks have three levels: in lv1, only one AI player in the scenes, in lv2, two AI players in scenes, in lv3, no less than three AI players will in the scenes. The patients in which scenes at which levels is controlled by researchers. According to the results, we find that after the training that the scores of the ASD patients are raised. Such results suggest that the VR technology could very helpful for the adjuvant therapy of the ASD.

Keywords: Virtual reality · Autism · Assistant training system

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1 Introduction

Autism as a pervasive developmental disorder it could lead the patients' social, communicative and behavioral functions impaired seriously. For adult patients of ASD, nearly two thirds of persons remain unable to provide basic personal care (Dorothy et al. 1998). The cost of health care and treatment across the lifespan of patients was up to $3.2 million (Ganz 2007; Peacock et al. 2012). It also would place a crushing burden on the poor patients and their families. For the adolescent patients, the lack of basic social and living skills could cause the difficulty to integrate themselves into the society. From the 1990s the prevalence of autism spectrum disorders increased rapidly (Mathew et al. 2014). The autism spectrum disorder (ASD) is now more and more focused by the psychologists and doctors. Many therapies appeared to address or relieve the symptoms which were caused by the ASD. The purpose of these methods is to help the patients possess basic social or living skills.

Previous intervention studies had utilized observational techniques, such as make a conversation during a simulated social party or a job interview (Howlin and Yates 1999). Self-rated questionnaires were also used by doctors (Hillier et al. 2007). These interventional therapies could improve the social communication skills of the adult patients of ASD significantly (Hillier et al. 2007). Although these methods were of power to relieve the symptoms of the ASD, but there are still some disadvantages of these therapies: (1) the simulation environment is the lack of immersion, the effectiveness of these methods was limited by the patients' imagination. (2) could not control the input stimuli, although the environment of the intervention was carefully designed but considered the uncontrollable in the real-world, the stimuli of the input was still not fully controlled. (3) safety of the learning situation, for the normal training methods, patients were forced to learn the social communication skills in a real environment which means it is not friendly to the ASD patients when they make mistakes.

With the rapid development of the technology, the virtual reality technology was utilized to overcome these disadvantages which could offer an immersion, fully controllable and friendly to the patients virtual training environment. The VR system can generate a special stimulation according to the training task and allow the experts to monitor the whole process and change the stimulation in time. Given the features of the VR system, it could offer fully immersed environment by using a helmet-mounted displays (HMD). Synthesize all of above characters, such system establishes a virtual but realistic enough training environment which allows the ASD patients to practice repeatedly and no need to be concerned about the mistakes.

Based further advantages of the VR system, psychologist and doctors could design more individualized training plans: the ASD patients may vary widely in their strength and weakness between different days. For a better treatment effect, doctors need to make more individualized treatment plan. To achieve the aim, experts will analyze the behavior data of the patient which is record by the training system or the experts themselves and make some change to the personal training plan properly. Such process also very slow and inefficient while with the help of the VR training system which based on computer system, it will be very efficient. The VR system stresses the response of visual

and auditory rather than touch. For the ASD patients, the visual and sight stimulation has been more helpful to teach them the abstract concepts, such as social skills.

2 Methods

2.1 Participants

Four volunteers took part in the experiment. (mean age 6 ± 1 year) which includes 1 female child. All participants had confirmed ASD diagnoses from a clinical doctor. Informed consent was obtained from the parents before participation. Each subject was required to complete two different checklists: (i) the Autism Behavior Scale table; (ii) the Childhood Autism Rating Scale table. The score of these two tables will be regarded as the baseline to the participant (Table 1).

Table 1. The basic scores achieved from the volunteers before the experiment.

Scores of baseline			
Subject ID	Sex	Scores of ABS	Scores of CARS
NJASD01	Male	75	45
NJASD02	Female	72	39
NJASD03	Male	78	46
NJASD04	Male	71	38

2.2 Experiment Paradigm

In this research, we establish an immersive virtual environment for children with ASD to improve their social communication skills.

The whole training paradigm is composite of three subsets which have different difficulty levels: in the 1st level, volunteers will communicate with single artificial intelligence actor which generated by the VR system. In the 2nd level, volunteers need interact with two AI actors with the same environment. In the 3rd level, participants will try to communicate with no less than three actors (Fig. 1). In each training task, the subjects must be finished such tasks: (1) tell the name, age to the AI actors; (2) do some daily communication with the AI actors; (3) follow the instruction given by the coach to have a rest (Fig. 2).

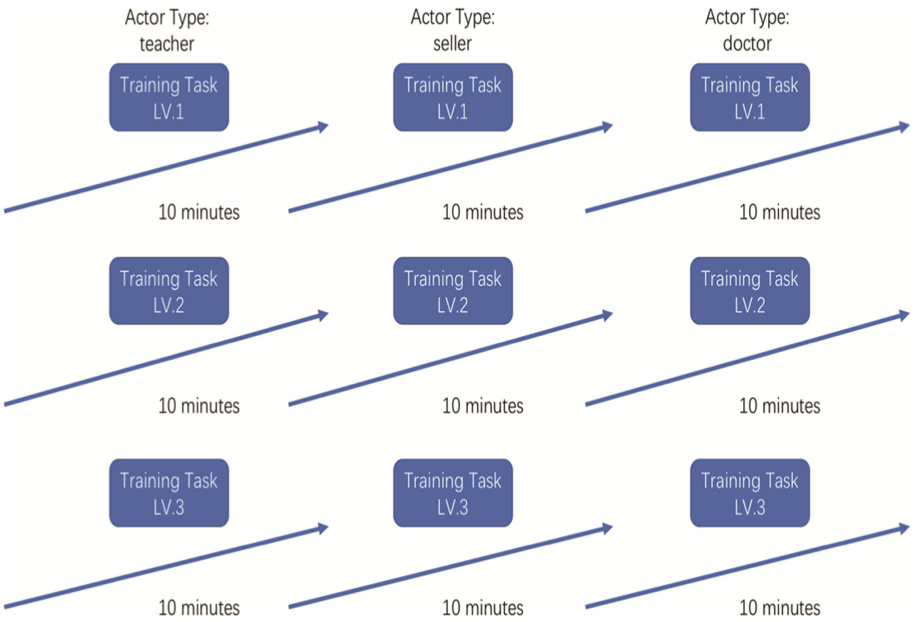

Fig. 1. Three levels in the training session. Each training task will be last 10 min and the task with different levels but has the same actor type will be executed sequentially.

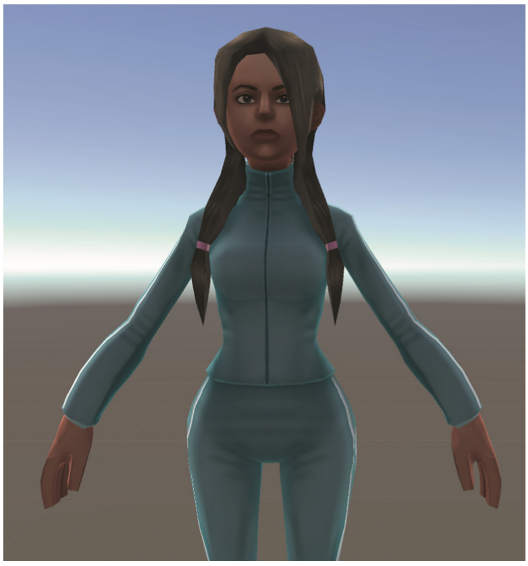

Fig. 2. A female coach which is displayed in the training task. Given that the female is more approachable and easy to be accepted by children with ASD, so in this study, we utilized a female avatar to act as the coach.

For all three levels, there are three different AI actor types: teacher, seller and doctor. Each training session will last 10 min. The coach will change the contents of the instruction which decide by the behavior of the volunteers. Before the formal experiment, a preliminary test will be executed first to make sure the participants will follow the instruction which is gave by the coach. The whole training process will last for 8 weeks.

2.3 Composition of Training System

The training system is composited by three components: application software; helmet-mounted-display device; a high-performance desktop computer (Fig. 3).

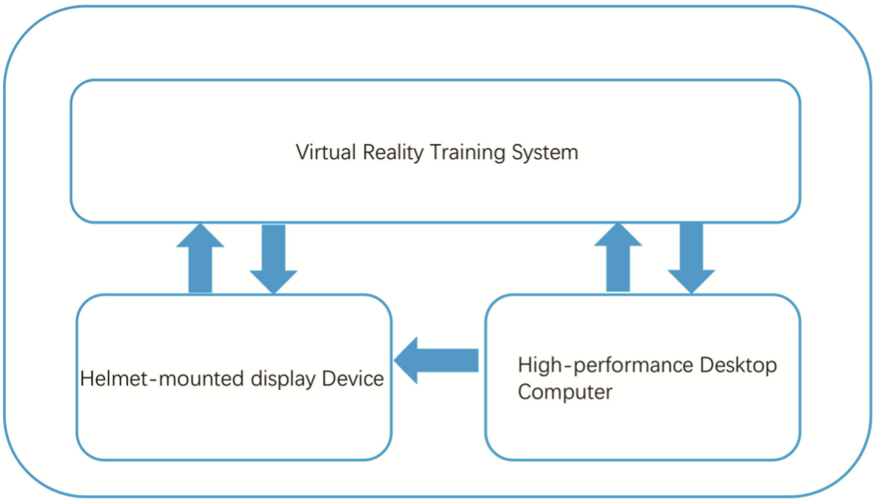

Fig. 3. The virtual reality training system was generated by using Unity3D software, when the subject training in the VR system researchers could monitor the situation of the patients and give the appropriate instructions.

The VR experiment system is generated by the Unity3D software (version 5.0). The whole VR system is running in a VR HMD system (HTC Vive).

3 Results

After each training session, participants were required to complete a rating scale which is used to assess the effectiveness of the task. The range of the checklist score is from 0 to 5 which 0 means difficult to accomplish and 5 represents easy to finish. The score of the task effectiveness listed in the Table 2.

Table 2. In order to assess the effectiveness of training tasks, after each task, participant will be required to answer a checklist.

Task effectiveness assessment										
ID	Sex	Teacher			Seller			Doctor		
		L1	L2	L3	L1	L2	L3	L1	L2	L3
NJASD01	Male	3	2	1	3	1	0	4	3	1
NJASD02	Female	4	3	2	3	3	2	5	3	2
NJASD03	Male	5	4	2	4	4	2	5	4	2
NJASD04	Male	4	3	2	4	3	3	5	3	2

Two checklists which the subjects were required to finish before the training sessions were graded again when the training process finished. The score of the two ASD diagnose checklists listed in the Table 3.

Table 3. Scores of the two checklists which obtained from the subjects after the training.

Scores of checklists			
Subject ID	Sex	Scores of ABS	Scores of CARS
NJASD01	Male	70	34
NJASD02	Female	68	32
NJASD03	Male	69	41
NJASD04	Male	64	30

Compared to the average scores of the ABS scale before and after the training, it shows that the scores of the ASD patients reduced. The former average score is 74 and the later average score is 67.75. According to the result of the independent t test analysis, the difference between two types was significant ($p < 0.05$). For the CARS scale, the

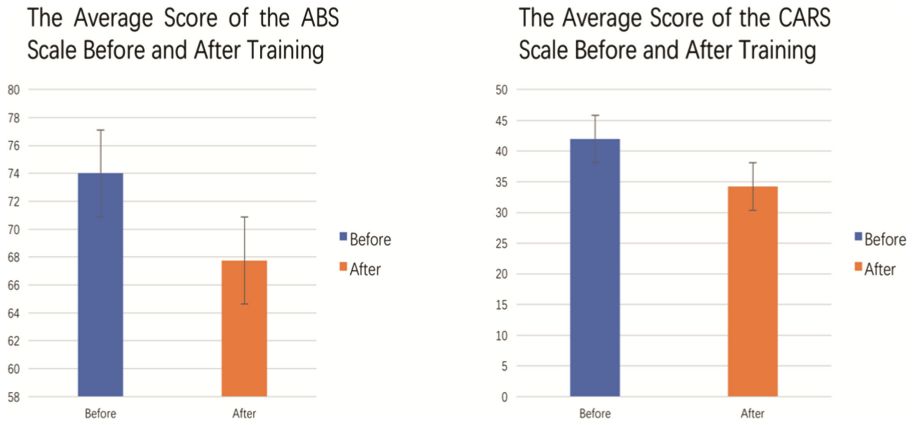

Fig. 4. The average scores of the two checklists (ABS, CARS) which obtained from the subjects before and after the training sessions.

former average score is 42 and the later score is 34.25. The difference between two types was significant ($p < 0.05$) (Fig. 4).

4 Discussion

Social communication as a very important skill, the lack of it would impaired the living quality of the ASD patients seriously. To improve the communication ability of the ASD patients, many methods were proposed by researchers. For example, Howlin et al. (1999). Proposed that utilized the observational techniques to improve the conversation skills of the adult ASD patients by establishing scenes of simulated job interview and social party. Hillier et al. (2007) make the ASD patients to observe the different types of conversation frequently. These methods could improve the communication skills of the ASD patients. But there are still some disadvantages for these methods: (1) uncontrollable stimuli; (2) could not change the training scenes in time; (3) the training time is not last too long.

Considering the rapid evolution of the VR technology, it has much powerful abilities to generate an immersive virtual world and has been considered as an effective tool to improve the social and life skills of ASD patients. A growing number of studies have examined applications of advanced interactive technologies to social and communication related intervention (Park et al. 2011; Rus-Calafell et al. 2014; Blocher and Picard 2002; Kozima et al. 2005; Parsons et al. 2004; Uttama et al. 2014). According to the results of this study, it shows that VR technology would helpful to raise the communication ability of the ASD patients, especially for the young children. Comparing the scores of two checklists which are obtained before and after the training tasks, it shows that the social communication skills of ASD children improved significantly by using the virtual reality training system. The VR training system not only allow the doctors to monitor the training process but also make the switching the training tasks in time possible. The VR system offers a safety and friendly virtual environment to ASD patients to practice their social and living communication skills.

Although the results of this study support the views that the VR training system could relieve the symptoms of the ASD patients, but there are still some disadvantages be founded during the experiment: considering the weight of the helmet-mounted display device, the time of the training task could not continue too long. During the training days, participants need come to the library on time which raise the cost of time. For some ASD patients who also suffered from the claustrophobia, they refused to take the helmet which lead the training interrupt. In the current version of the VR training system, the helmet-mounted-display device was used the HTC Vive which is a high-performance device. Although the display effect was good, but the portability of it was bad because it has to be connected to the computer by some cables. Considering the treatment which patients need to utilize the training system at home and practice for a long time that the whole system should be robust and easy to maintaining.

For future research, we plan to import the eye-tracking and facial-tracking technologies into our training system. This would promise the human-computer interaction of VR training system more naturalistic and flexible. For the HMD device, it is planning

to add a wireless suite to the HTC Vive which could allow the device connects to the computer without using the cables. Considering the similarity degree between AI actors and human beings could affect the training effectiveness, further research paradigm will be design.

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